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EFFECT OF RESIDUE MANAGEMENT ON PREDICTED SOIL LOSS

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INTRODUCTION

The Food Security Act of the 1985 and 1990 Farm Bills required conservation plans for highly erodible land (HEL) if farmers wanted to participate in farm programs. Conservation farming plans were developed based on predicted average annual soil loss. These soil loss predictions were made using the USLE (Universal Soil Loss Equation) erosion model described by Wischmeier and Smith (1965 and 1978). An updated version of USLE called RUSLE (Revised Universal Soil Loss Equation) is now available on diskettes for PC's (Personal Computers) from the Soil and Water Conservation Society, Ankeny, Iowa. NRCS (Natural Resources Conservation Service) uses RUSLE to help guide farmers in developing conservation management systems.

RUSLE is the third version of USLE. It is an empirical equation derived from theory of erosion processes and a vast amount of data from natural runoff and rainfall simulator plots (Renard et al. 1996). The RUSLE equation is as follows:

$$A = RK(LS)CP$$

A is average annual soil loss from sheet and rill erosion in tons per acre per year. R is a rainfall-runoff erosivity factor that is composed of a rainfall erosion index plus a factor for runoff associated with snowmelt. R is expressed in units of hundreds of foot ton inches per acre hour year. K is soil erodibility; a factor that accounts for the influence of soil properties on erosion and is determined from data collected on plots managed under a standard set of conditions. K has units of ton acre hour per hundred acre foot ton inch. LS is a combined effect for slope length and slope steepness and is dimensionless. C is a factor for crop residue and cover management and is dimensionless. P is a dimensionless factor for support practices such as contour and stripfarming.

The objectives of this research were to use RUSLE to compare predicted soil loss from four tillage and residue management systems and to provide an opportunity for exchange of soil erosion technology with Mr. H. Liu, a visiting scientist from China.

MATERIALS AND METHODS

Data from a winter wheat/summer fallow crop residue management experiment located adjacent to Wildhorse Creek near the Columbia Plateau Conservation Research Center was used to demonstrate the use of RUSLE. This experiment had four treatments providing different primary tillage and amounts of crop residue on the soil surface after seeding winter wheat. Treatment 1 used chisel plowing as the primary tillage. Moldboard plowing was the primary tillage for treatments 2, 3 and 4. Residue was removed before plowing in treatments 3 and 4 and returned to the soil surface after plowing. Treatments 3 and 4 had 1,800 and 5,500 lb per acre of residue placed on the soil surface after moldboard plowing, respectively. Secondary tillage during the fallow summer was the same for all plots. After seeding, residue cover was measured by the line transect method and found to be 39, 9, 21 and 38 percent for treatments 1, 2, 3 and 4, respectively.

A combination of the RUSLE Field Office Technical Guide (USDA, 1995) and the computer version of RUSLE (Soil and Water Cons. Soc., Ankeny, Iowa) was used to determine RUSLE factors R, K, LS, C and P. The procedure was as follows:

1. Erosivity Factor R:

When RUSLE is used to estimate sheet and rill erosion in the dryland crop areas of the Pacific Northwest the effect of melting snow, rain on snow, and/or rain on thawing soil poses unique problems. Soil losses in this region are much greater than the values that might be expected from conventional R values. Therefore, an R equivalent (R_{eq}) is used instead of the conventional R. R_{eq} was selected by locating the site on the county R_{eq} map and selecting R_{eq} from the closest isoerodent (R_{eq}) line (USDA, 1995). The R_{eq} value was found to be 60.

2. Soil Erodibility Factor K:

In Oregon, Kf values are used for the K factor in RUSLE. Kf represents soil erodibility of fine soil (<0.08 inches). From the Soil Survey Map of Umatilla County Area, the soil at this site is Walla Walla Silt Loam and the Kf value is 0.43 (USDA, 1988).

3. Slope Length and Steepness Factor LS:

The slope length/slope steepness factor (LS) includes the combined effect of slope length and steepness on erosion. LS represents how erodible the particular slope length and steepness is relative to the 72.6 ft. long, 9 percent steep, standard USLE plot. Slope length and steepness at this site were measured and found to be 250 feet and 23 percent, respectively. LS values were calculated with the computer version of RUSLE and found to be 3.21.

4. Support Practices Factor P:

The effects of supporting practices like contouring, stripcropping, and terraces are described by the P factor in RUSLE. Support practices are often used in combination. In this case, contouring and cover-management were used. Cover management conditions were classified as condition 5, "Light cover and/or moderate roughness (Table 1, "Cover Management Conditions", USDA, 1995). The site was seeded on contour with a double disc drill. Factor P was determined by identifying the site characteristics hydrologic soil group, slope gradient and length, grade along furrows, and 10-year storm erosivity (10-yr EI). Using this information, P was determined from the appropriate table (USDA, 1995). The site characteristics used to determine critical slope length were as follows:

a) Hydrologic soils group C (moderately high runoff potential).
b) Landscape profile slope was 23 percent, and the horizontal slope length was 250 feet. Furrow grade was 0.0 percent.
c) For a dryland farm site near Pendleton, the 10-yr EI = 10 (USDA, 1995).
d) Small grain with cover-management condition 5.
e) A ridge height of 1.5 inches is classed as a very low ridge.
f) Seeded on contour.

P subfactor value was determined to be 0.59 (Table 3 section II , USDA, 1995). Because the furrow grade was 0.0 percent, there was no need to adjust P.

The critical slope lengths was 680 ft for hydrologic soil group C, 23 percent

slope, 10-yr EI = 10, and cover and management condition 5 (Figure 31, USDA, 1995). The critical slope length exceeded the 250 feet slope length and therefore the P subfactor value was applied without adjustment.

5. Cover-Management Factor C:

The treatments at the Wildhorse Creek Site represent four cover-management systems. The treatments were as follows. Treatment 1 = chisel plowing. Treatment 2 = moldboard plowing (traditional tillage). Treatment 3 = mow-plow ; 1,800 pounds of residue per acre. Treatment 4 = mow-plow ; 5,500 pounds of residue per acre. Crop residue cover measurements from the field site on October 5 and 6, 1995 after seeding these plots were 39 , 9 , 21, and 38 percent for treatments 1, 2, 3, and 4, respectively. The RUSLE C values for winter wheat/fallow crop rotation, producing 60 bushels of grain per acre, seeded early and having residue covers of 39, 9, 21 and 38 percent, were determined by the computer program and found to be 0.038, 0.13, 0.087, and 0.04 for treatments 1, 2, 3, and 4, respectively.

RESULTS AND DISCUSSION

Average annual soil loss caused by rainfall as predicted by RUSLE for these tillage and site conditions varied from 1.9 to 6.4 tons per acre per year (Table 1).

C was the only RUSLE factor that was different for the four treatments. The variation in predicted soil loss was due to the amount of surface residue cover. There is no differentiation made for the variation in the nature of the surface residue or the influence of maintaining the crop residue near the soil surface. Chisel plowing incorporates residue in the top 4 inches (Wilkins and Kraft, 1988) and this includes wheat plant crowns. The moldboard plow buries wheat crowns more than 4 inches deep. If these treatments were practiced continuously, it is possible that the infiltration characteristics of the surface soil would be different between soil that was chisel plowed and moldboard plowed.

RUSLE is an erosion model designed to predict the longtime average annual soil loss by runoff from specific field

Table 1. Average annual soil loss at Wildhorse Creek site located near Pendleton, Oregon.

Treatment	Residue Cover	RUSLE factors R_{eq} [†]	Kf[‡]	LS	C	P	Soil Loss A[§]
	%						
Chisel plow	39	60	0.43	3.21	0.038	0.59	1.9
Moldboard plow	9	60	0.43	3.21	0.130	0.59	6.4
Mow-plow - 1,800 lb/ac of residue	21	60	0.43	3.21	0.087	0.59	4.3
Mow-plow - 5,500 lb/ac of residue	38	60	0.43	3.21	0.040	0.59	2.0

[†] R_{eq} has units of hundreds of foot ton inches per acre per hour per year.
[‡] K has units of ton acre hour per hundreds of acre per foot per ton per inch.
[§] A is shown in tons per acre per year.

slopes in specified cropping and management systems. RULSE is not designed to predict soil loss from individual events.

Field measurements of runoff and soil loss associated with natural runoff events and simulated rainfall are being collected at this site. It will be interesting to see if predicted soil loss and measured loss agree.

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